ACCOMMODATING INTRAOCULAR LENS

BACKGROUND-FIELD OF INVENTION

This invention relates to intraocular lenses, specifically to intraocular lenses which have the ability to alter their refractive power in response to changes in the tension of the ciliary muscle of the eye.

BACKGROUND-DESCRIPTION OF PRIOR ART

The first implantation of an artificial lens into a human eye was carried out by Ridley in 1949. Since then several million intraocular lenses have been implanted in the eyes of cataract patients. Today the vast majority of cataract operations involve the implantation of an artificial lens. However, with the exception of a very few experimental lenses these implanted lenses have a fixed focal length or, in the case of bifocal or multifocal lenses, have a few different fixed focal lengths. These lenses therefore lack the ability of the natural lens to change power so as to be able to focus sharply on the retina objects at a continuum of distances from the eye.

Some previous attempts have been made at creating accommodating intraocular lenses. A simple way of varying the effective power of an intraocular lens is by equipping a single fixed power lens with attachments so that it may move back and forth along the optical axis of the eye in response to changes in tension in the ciliary muscle (U.S. Pat. No. 4,254,509 to Tennant 1981; U.S. Pat. No. 4,790,847 to Woods 1988). However, it appears that only a limited amount of change in refractive power can be achieved in this manner (Thornton, 1986).

Hara et al. (1990, 1992) created a system consisting of two lenses held together in a spring arrangement. Accommodation occurs by varying the distance between the lenses. An obvious problem with this system is that it necessarily depends on very fine and fragile springs which could easily be damaged in handling.

Another attempt at creating an accommodating intraocular lens (U.S. Pat. No. 4,932,966 to Christie et al. 1990) has been to use a liquid filled lens to which are attached liquid filled bladders. The bladders and the lumen of the lens are in free communication. The whole assembly is placed inside the empty lens capsule, in such a way that the pressure from the lens capsule is transmitted to the bladders. Increased pressure on the bladders makes liquid move from the bladders to the lumen of the lens, so as to increase the volume (and pressure) of the lens and make it take on a more curved shape. This causes the lens to increase its power. The drawbacks with this approach are that the lens is large and cannot easily be compressed for implantation. Because of its large size it may be difficult to implant and may require large incisions in the cornea. Large corneal incisions are associated with postoperative astigmatism. Also, in order to function properly the lens requires that the lens capsule is left relatively intact, which may be difficult to achieve considering that, due to the large size of the lens, a large incision in the lens capsule is required for placing the lens in the capsule. Furthermore, in order for the lens to work it needs to be filled with a liquid with substantially higher refractive index than that of the surrounding aqueous. While such liquids exist it may turn out to be difficult to find one which will not harm the eye if the lens were to accidentally rupture. For example, filling the lens with oil, as was suggested by Christie et al, may not be safe since the oil may, following accidental rupture, find its way to the anterior chamber and block the angle so as to cause glaucoma. A further difficulty

associated with this design is the need to be able to fill the lens with liquid without trapping air in the process.

While most intraocular lenses have a convex shape, concave lenses (U.S. Pat. No. 4,704,122 to Portnoy 1987) or lenses having concave elements (U.S. Pat. No. 4,074,368 to Levy and Pegis 1978) have been proposed. In order to provide positive power these concave elements need to be filled with a substance of refractive index less than that of the surrounding material. Stoy and Stoy (U.S. Pat. No. 4,731,078; 1988) described a variable power lens which incorporates optical materials of low refractive index. However, none of these inventions which have made use of concave elements have incorporated means whereby the tension in the ciliary muscle can dynamically control the power of the lens.

OBJECTS AND ADVANTAGES

Several objects and advantages of the present invention are:

(a) to provide an intraocular lens with the ability to alter its refractive power in response to changes in tension of the ciliary muscle, so as to bring to focus on the retina images of objects over a continuous range of distances, i.e. to accommodate;

(b) to provide an accommodating intraocular lens which is simple in design so as to be easy to manufacture;

(c) to provide an accommodating intraocular lens that is compatible with standard procedures for extracapsular cataract surgery (which may involve capsulectomy of a substantial portion of the anterior capsule);

(d) to provide an accommodating intraocular lens with few moving parts so as to reduce the risk of irritating delicate tissue in the eye thereby reducing the chance of inflammation;

(e) to provide an accommodating intraocular lens which is of light weight so as to put little load on the areas where it makes physical contact with structures of the eye;

(f) to provide an accommodating intraocular lens which is safe, and does not rely on liquids which may be toxic to the tissue of the eye or which may cause glaucoma should these liquids be accidentally released into the interior of the eye;

(g) to provide an accommodating intraocular lens which can be built using materials currently available for use in intraocular implants;

(h) to provide an accommodating intraocular lens which can be implanted using essentially established surgical procedures so as not to require surgeons to undergo substantial re-training;

(i) to provide an accommodating intraocular lens which, for its refractive power, relies on a medium with a refractive index substantially different from that of the surrounding aqueous thereby not requiring very curved refracting surfaces, which in turn allows the lens to occupy only a small volume, i.e. it can be very thin, and has the additional advantage of making it possible to change lens power with only minor changes in lens shape and volume;

(j) to provide an accommodating intraocular lens which is robust and whose various optical parts cannot easily become misaligned.